Evaluation of centrality in Au+Au centrality classes. Glauber Model calculation including Ncoll bias for hard probes signatures.

Ginés MARTINEZ and Thierry VISONNEAU*.

SUBATECH BP20722, 44307 Nantes Cedex 3, France

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abstract

This note presents the calculations of $< N_{coll} >$ and $< N_{part} >$ in minimum bias events in coincidence with a high p_T $\pi°$ production. The outcome of the present analysis could slightly change the observed pattern in our results concerning high p_T $\pi°$ suppression as a function of $< N_{part} >$ (PHENIX coll. Phys. Rev. Lett. 91, 072301 (2003)).

I. INTRODUCTION

In a recent letter [1] we presented the evolution of the nuclear modification factor R_{AA} for high p_T $\pi°$ ($p_T > 4.0$ GeV/c) for different classes of centrality (see Fig.1). We decided to use $< N_{part} >$ as a measurement of the centrality for each centrality class. It was calculated by means of the Glauber model [2]. *Grosso modo*, $< N_{part} >$ is computed as the average number of participants of all the events presented in a given centrality class and for this reason we denote it here as $< N_{part} >_{evt}$. However, in the Fig.1 (Fig.3 in [1]), we have added a condition to the centrality class: a high p_T $\pi°$ (>4 GeV/c) should be produced. Naively, one could expect a bias in the centrality-class, since only events producing a high p_T $\pi°$ are considered here. To take properly into account this bias, we propose in this note that the centrality of the class should be then given by $< N_{part} >_{\pi°}$ which represents the average

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*Student of Licence de Physique of Nantes University. Research interniship at Subatech June - August 2003.

number of participants for the events present in the concerned centrality class *and* producing

a high p_T π°.
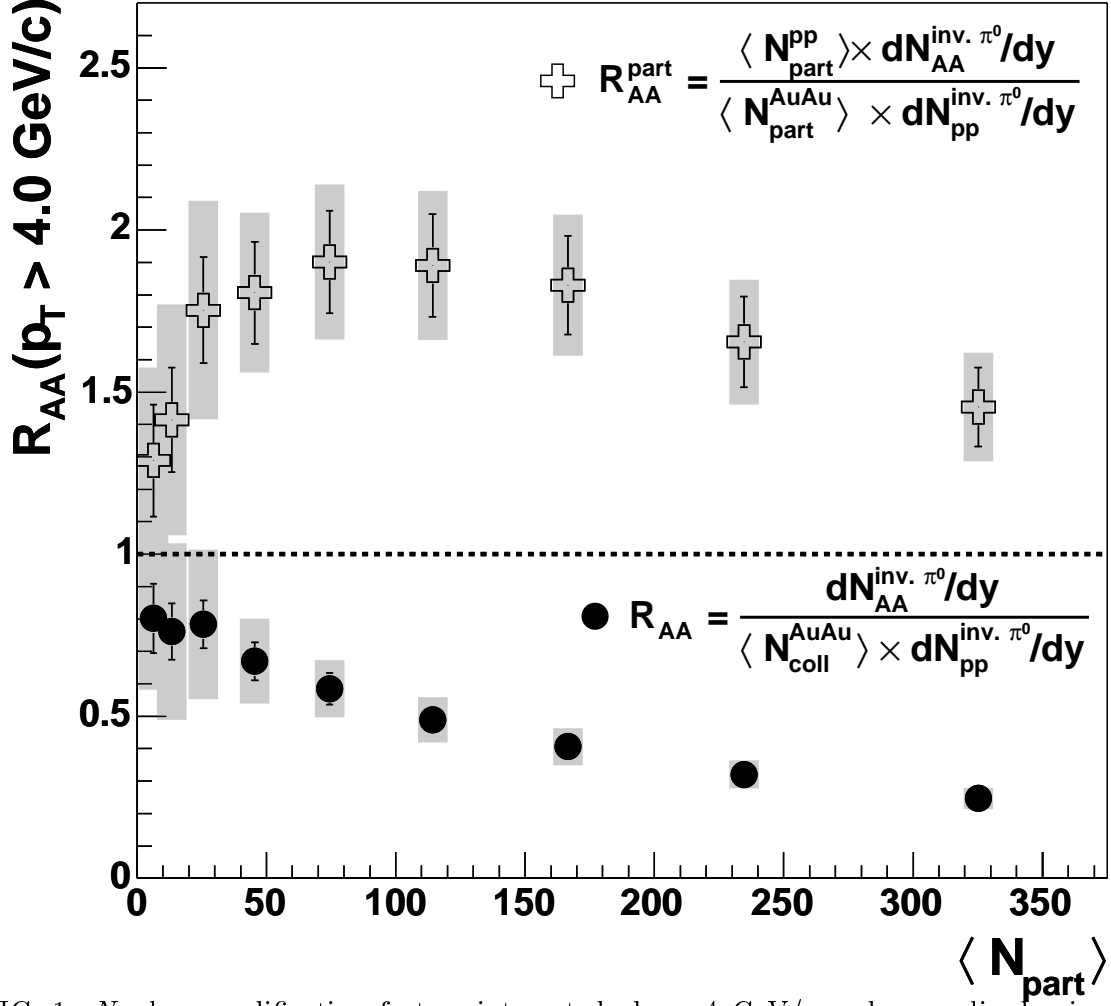
FIG. 1. *Nuclear modification factors integrated above 4 GeV/c and normalized using N_{coll} (circles) and N_{part} (crosses), as a function of centrality given by N_{part} (from [1]).*

II. CENTRALITY EVALUATION

For a given centrality class we define the nuclear modification factor as:

$$R_{AA}^{CC} = \frac{N_{\pi^\circ}^{CC}}{< N_{coll} > \times N_{evt}^{CC} \times \sigma_{NN}^{\pi}/\sigma_{NN}} \tag{1}$$

where $N_{\pi^\circ}^{CC}$ is the number of produced π°'s in the centrality class CC, N_{evt}^{CC} is the number of events, $\sigma_{NN}^{\pi}/\sigma_{NN}$ is the normalisation with respect to pp collisions and $< N_{coll} >$ is the average number of collisions for this centrality class.

Let's assume that $f(N_{part})$ represents the distribution of the number of participants for the centrality class CC. We get the following expressions:

$$< N_{coll} >= \frac{\int N_{coll}(N_{part}) \times f(N_{part}) \times dN_{part}}{\int f(N_{part}) \times dN_{part}} \tag{2}$$

$$N_{evt}^{CC} = \int f(N_{part}) \times dN_{part} \tag{3}$$

$$N_{\pi^\circ}^{CC} = \alpha \times \int R_{AA}(N_{part}) \times N_{coll} \times f(N_{part}) \times dN_{part} \tag{4}$$

Then, we get from the four previous expressions that:

$$R_{AA}^{CC} = \frac{\int R_{AA}(N_{part}) \times N_{coll} \times f(N_{part}) \times dN_{part}}{\int N_{coll} \times f(N_{part}) \times dN_{part}} \tag{5}$$

so R_{AA}^{CC} is the mean value of $R_{AA}(N_{part})$ weighted by the distribution $N_{coll} \times f(N_{part})$:

$$R_{AA}^{CC} =< R_{AA}(N_{part}) >_{N_{coll} \times f(N_{part})} \equiv < R_{AA}(N_{part}) >_{\pi^\circ} \tag{6}$$

Furthermore, if we assume a local linear depedence between R_{AA} and N_{part} for a givien centrality class [1]:

$$R_{AA}(N_{part}) = p_0 + p_1 \times N_{part} \tag{7}$$

we finally obtain that :

$$R_{AA}^{CC} = R_{AA}(< N_{part} >_{N_{coll} \times f(N_{part})}) \tag{8}$$

Therefore the centrality of a given centrality class should be:

$$< N_{part} >_{\pi^\circ} \equiv < N_{part} >_{N_{coll} \times f(N_{part})} = \frac{\int N_{part} \times N_{coll} \times f(N_{part}) \times dN_{part}}{\int N_{coll} \times f(N_{part}) \times dN_{part}} \tag{9}$$

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[1]This is a relatively good assumption for 10% centrality classes, although is not so good for minimum bias class.

III. EVALUATION OF CENTRALITY

We can calculate the centrality of each centrality class from the MonteCarlo glauber package developped by Klaus REYGERS (from cvs: offline/analysis/glauber_mc and new macro glauber_hard.C). We only need to weight the distributions by the number of collisions N_{coll} in each glauber event.

As an example, fig.2 presents the distribution of N_{part} for the centrality class 70%-80% weighted and non-weighted.
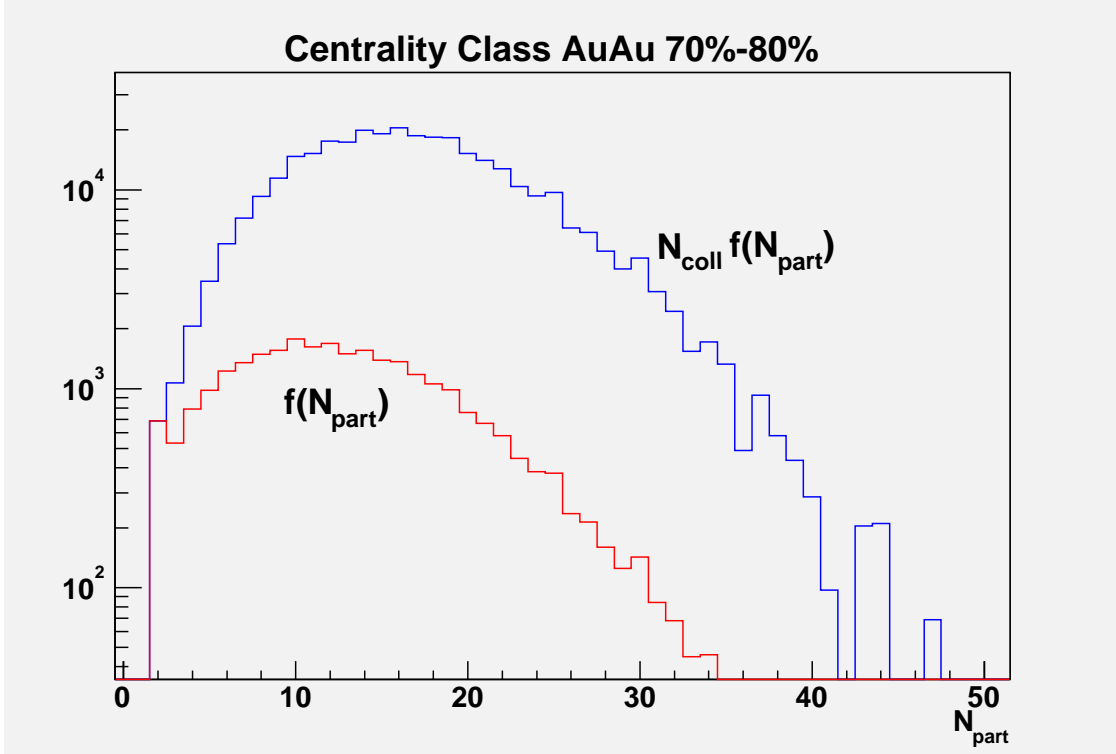

FIG. 2. *Distribution of N_{part} for the centrality class 70%-80% weighted and non-weighted.*

Table III repports the values of centrality for each centrality class for Au+Au collisions $< N_{part} >_{\pi^\circ}$. We observe than the mean value of participants (or collisions) per each centrality class is larger when one considers the weight on N_{coll}. The effect is specially important for the most peripheral collisions where there is an increase of more than 50%.

CC(% events)	R_{AA}	$< N_{part} >_{evt}$	$< N_{coll} >_{evt}$	$< N_{part} >_{\pi^\circ}$	$< N_{coll} >_{\pi^\circ}$	$\Delta N_{part}/N_{part}$
0%-10%	0.248	325.2	955.4	329.8	978.9	1.4%
10%-20%	0.338	234.6	602.5	238.7	621.9	1.7%
20%-30%	0.418	166.6	373.8	170.3	390.2	2.2%
30%-40%	0.507	114.3	219.9	117.7	233.1	3.0%
40%-50%	0.557	74.4	120.5	77.6	130.6	4.3%
50%-60%	0.681	45.6	61.1	49.0	69.2	7.4%
60%-70%	0.824	25.7	28.6	29.6	35.2	15.2%
70%-80%	0.771	13.2	12.2	17.2	17.3	30.3%
80%-92%	0.776	6.3	4.9	9.6	8.2	52.4%
Min.Bias	0.373	109.5	258.8	236.2	642.3	115.7%

TABLE I. R_{AA} values for π° with p_T=4.0-4.5 GeV/c from reference [3].   Values of $< N_{part} >_{evt}$ and $< N_{coll} >_{evt}$ obtained for each centrality class in the present Glauber calculation are in agreement with the published values [1]. Values of $< N_{part} >_{\pi^\circ}$ and $< N_{coll} >_{\pi^\circ}$ are calculated taking into account the weight on N_{coll}.

IV. RAA DEPENDENCE ON CENTRALITY

In fig.3 we compare the result of the R_{AA} dependence as a fonction of N_{part}, taken $< N_{part} >_{evt}$ as in [1] or $< N_{part} >_{\pi^\circ}$ as it should be.
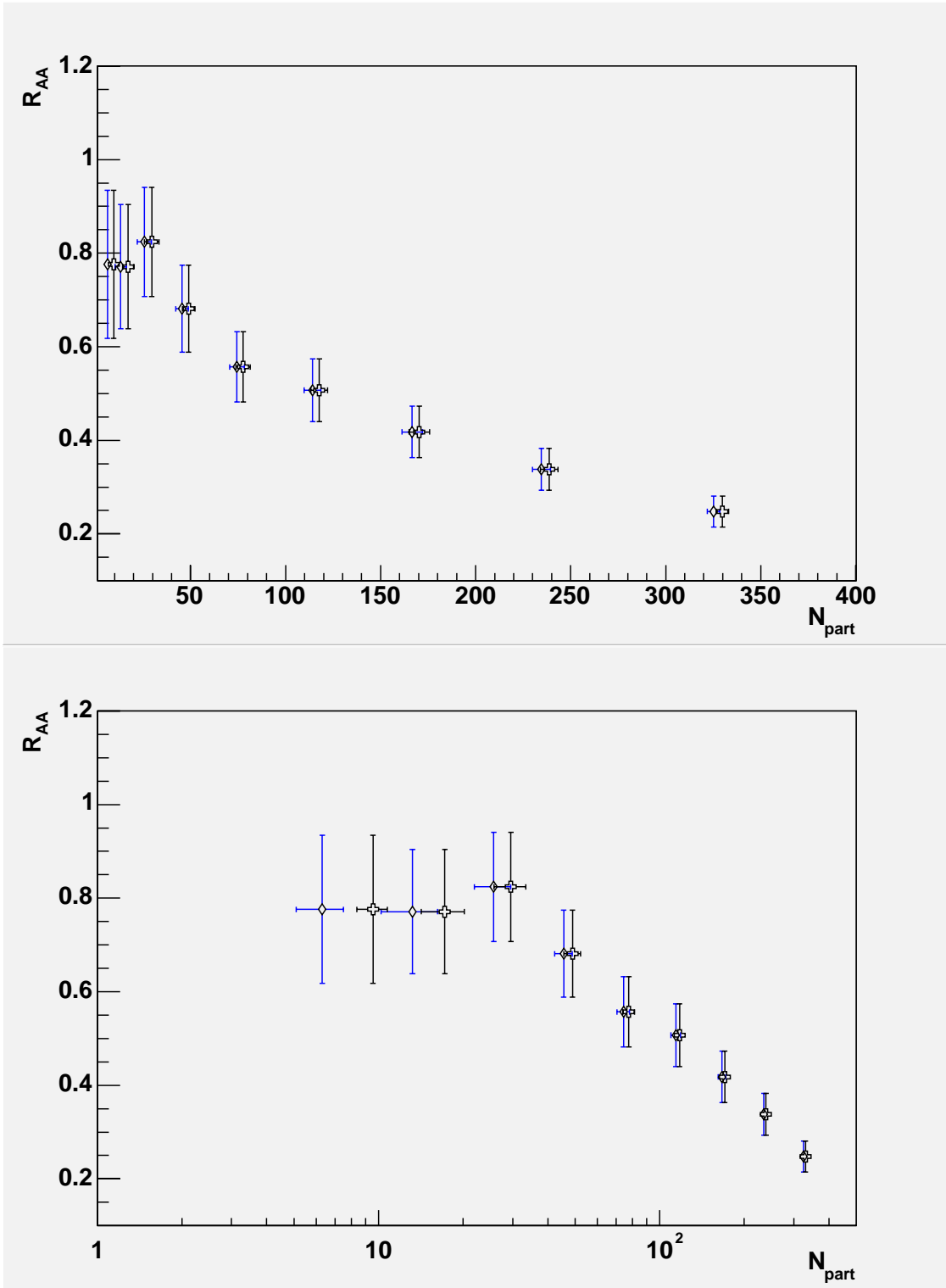
FIG. 3. R_{AA} dependence as a fonction of N_{part} for high p_T π°'s (p_T = 4.0-4.5 GeV/c) in linear and log scale for non-weighted distribution (diamonds) and weighted distributions (crosses).

V. CONCLUSIONS

Of course the present analysis is also applicable for other hard probes like high p_T charge hadrons, quarkonia, etc ...

VI. ACKWNOLEDGEMENTS

REFERENCES

[1] PHENIX Coll. Phys. Rev. Lett. 91, 072301 (2003).

[2] PHENIX Analysis Note 169 "Glauber Monte Carlo calculations for Au+Au at sqrt(s_NN) = 200 GeV" Klaus Reygers (Feb-2003), http://www.phenix.bnl.gov/ WWW/ p/ draft/ reygers/ glauber_note_200gev/

[3] PHENIX Analysis Note 186 "Update of "Suppressed pi0 Production at Large Transverse Momentum in Central Au+Au Collisions at sqrt(s_NN) = 200 GeV" D. d'Enterria et al., https://www.phenix.bnl.gov/ WWW/ p/ draft/ enterria/ ppg014/